APPENDIX 1

PRECOGNITION — A MEMORY OF THINGS FUTURE?

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To be presented at the Conference on Quantum Physics and Parapsychology

Geneva, Switzerland, August 26-27, 1974

theories is quite different than the above picture would suggest. Instead of forbidding precognition from happening, these theories typically have sufficient symmetry to suggest that phenomena akin to precognition should occur in a manner qualitatively, although not necessarily quantitatively, similar to the occurrence of retrocognition. Indeed, phenomena involving a reversed time order of cause and effect are generally excluded from consideration on the ground that they have not been observed, rather than because the theory forbids them. This exclusion itself introduces an element of asymmetry into the physical theories, which some physicists have felt was improper, or required further explanation.[2] Thus, if such phenomena indeed occur, no change in the fundamental equations of physics would be needed to describe them. Only a change in the solutions used would be necessary.

The details of these aspects of physics relevent to this possibility will be given below. However, it is worth noting first that the occurrence of physical effects that propagate backwards in time may be related to precognition very indirectly. To see this, we note that the information about the past that is available to any person at a given time does not mainly consist of his sense data at that instant. Indeed, we usually do not think of sense data as giving information about the past, although strictly speaking it is the past we are observing, because of the finite time required for any known type of signals to propagate across space. Instead, our information about the past comes either from inferences we make from these observations, or through the poorly understood process we call memory, through which we can bring into our present awareness observations that we, or others, have made in the past, and which have somehow been stored in our brains.

A plausible analogy between information about the past and future would suggest that if information about the future is available to a person at all, the main source of it might well be observations that he or others will make in the future, and which will then be stored in his brain. It might be expected that whatever the mechanism of precognition, it could work more easily upon the future state of the percipients own brain than on the world outside. In other words, I am suggesting that precognition, if it exists, is basically a remembrance of things future, an analogy to memory, rather than a perception of future events, an analogy to sense perceptions of the very recent past. This suggestion has at least the merit of being fairly easy to test through simple experiments, or perhaps even through a careful literature search. I shall spell out below some of the simple consequences of this model for precognition, and how to test it. If it is correct, it would not directly indicate the physical mechanism for precognition, any more than the existence of memory indicates its physical mechanism. However, if it does turn out that memory can operate into the future as well as into the past, it would suggest that the symmetry of physical laws mentioned above is involved, and that physicists have been premature in discarding those solutions to their equations that describe reversed time order of cause and effect.

II. Time Symmetry of the Equations of Physics

The equations that describe the evolution in time of physical phenomena take a rather simple form according to relativity theory. A typical example, which illustrates the main points, is the wave equation in one space dimension, whose form is:

$$\frac{\partial^2 \phi}{\partial x^2} - \frac{1}{c^2} \frac{\partial^2 \phi}{\partial t^2} = \rho(x, t) \qquad (1)$$

where c is the velocity at which the waves move through space. In this equation, ϕ represents the amplitude of some wave phenomenon, and ρ a material source for the wave. For instance, ϕ might represent an electric field strength, and ρ the distribution of charge or current that produces the field. In a physical application of this equation, we would take ρ to be a prescribed function of space and time, and use the equation to calculate ϕ for all values of x and t. The values obtained for ϕ will depend on the value of ρ, but in a rather complex way. However, generally speaking, a change in ρ at one point in space and time, will lead to a change in ϕ at many points in space and time, in a way prescribed by the equation. A human being, or an instrument, sensitive to the value of ϕ in some region of space-time will therefore receive different impulses depending on the value of ρ in other regions of space-time, and hence will know something about what is happening in those other regions. Clearly, the relation between ρ and ϕ is a critical factor in determining what regions of space-time are accessible to a particular observer through measurement or sensing of the value of ϕ at his location.

Because equation (1) is a second order partial differential equation in the time, it has in general two sets of solutions. The particular form of equation (1) is such that one set can be obtained from the other set by the change of t into $-t$, in both ϕ and in ρ. We can study the character of these solutions by considering the simple case in which ρ is a transient disturbance, such as a light bulb that is turned on and off in a short period of time, and is limited to a small region of space. We shall call the point at which ρ is localized x_o, t_o. The solutions for this case can then be described as follows. One solution, called retarded, has $\phi = 0$ for all times earlier than t_o, everywhere in space. For times after t_o, ϕ is non-zero at the points $x = x_o \pm ct$. This corresponds to the generation of two pulses of radiation, each travelling outward from the source point at velocity c. An observer at a distance d from the point x_o would detect this radiation at a time t, later than t_o by d/c, the time taken for the radiation to travel the distance d. This retarded solution is the one generally chosen to represent the physical phenomena described by the wave equation.

The other solution, obtained from the retarded solution by letting $t \rightarrow -t$, is known as the advanced solution. It has the property that $\phi = 0$ for t later than t_o, everywhere in space. For t earlier than t_o, ϕ is non-zero at the points $x = x_o \pm ct$. This solution may be interpreted either as two pulses of radiation travelling outwards from the source, but backwards in time, or as two pulses coming from spatial infinity, but forwards in time, to meet at the source at t_o. With either interpretation of the advanced solution, there is associated with the disturbance at t_o, effects at times earlier than t_o, rather than later than t_o, as for the retarded

solution. An observer at a distance d from the point x_o would detect the radiation corresponding to the advanced solution at a time t, earlier than t_o by d/c. In the case of an electromagnetic wave, travelling at the speed of light, this time is usually very short. When d corresponds to a distance of a few meters, d/c is about 1/100 of a microsecond, so that the advanced notice of a disturbance available in this way would not be very useful. If one considers waves propagating more slowly, such as sound waves, the advanced notice would be somewhat longer, but still too short to be directly useful for precognition. However, indirect effects of advanced waves are more promising, and will be discussed below.

Whatever use we could make of advanced waves, we must first ask whether they actually occur in the world, as against occurring as mathematical solutions to equations. The general solution to equation (1) is a linear combination of the retarded and advanced solutions, with unknown coefficients. As mentioned above, physicists have usually, although not always,[2] supposed that the coefficient of the advanced solution is zero, and only the retarded one is present. The reason for this is that advanced effects do not appear to occur, at least within some range of accuracy. The evidence for this is simple. If there were advanced effects comparable in size to retarded ones, many bizarre astronomical phenomena would be observed. For example, two images would be seen of a planet, or other astronomical objects, displaced by the distance that the object moves in twice the time it takes light to go from the object to earth. For the planet Mars, these images would be displaced by more than the planets apparent diameter, and would have been easily detected. Another example is that phenomena that occur at a well defined time at the place of origin, such

as eruption of a solar prominence , would appear to occur twice in the same spot, once corresponding to the arrival of the advanced wave, and then later corresponding to the arrival of the retarded wave. Since these phenomena have not been reported by astronomers, we may conclude that advanced waves are not as strongly produced as retarded waves.

However, this does not imply that they are not produced at all. Conceivably, the ratio of strength of advanced and retarded waves is quite small, but not zero. This would not necessarily make the advanced waves useless for precognition, but would rather imply that precognition would not be as effective as ordinary perception, or as memory of the past, a conclusion for which there is ample evidence. Experiments to detect a relatively small amount of advanced light wave are not hard to imagine, and I have suggested some, that may soon be carried out by Prof. Riley Newman of the University of California. In the simplest such experiment, a light source is turned on at a time that is very sharply defined, say to within 10^{-9} seconds. A detector is placed at a distance of 10 meters from the source. The detector will ordinarily indicate the presence of the retarded wave after about 3×10^{-8} seconds have passed, corresponding to the transit time of the light over the 10 meters. If an advanced wave is also present, the detector would react to it at a time 3×10^{-8} seconds before the light is turned on, and this time is large enough that the advanced and retarded signals are easily distinguished. The consequence of not turning on the light after the advanced signal is detected is left to the reader to consider. Professor Newman believes that an advanced wave of intensity as little as one part in 10^{19} of the retarded wave could be detected in this way, so we should

soon know if advanced electromagnetic waves occur. Advanced solutions for other kinds of wave motion, such as sound can be treated by similar mathematics. However, since these motions generally involve a real medium through which the wave moves, such as the atmosphere, it is unclear whether the interpretation would be the same. No experimental evidence about such advanced solutions is known to me.

III. A Model for Precognition

In the following, I shall outline a very speculative model for precognition that relies on advanced waves. The model is qualitative rather than quantitative, because it involves workings of the brain, where detailed physical information is unavailable. Yet I believe that model is sufficiently precise that it can easily be tested, providing that precognition can be demonstrated at all.

We assume that when some sensory input reaches the brain, an oscillatory variation of some internal patterns in the brain occurs, which is specific to the input. This oscillation persists for some period of time in at least part of the brain. When the person involved remembers the stimulus, what has happened is that the stored oscillatory pattern has influenced another part of the brain, bringing the memory into consciousness, or at least into something accessible to consciousness. Those familiar with the literature on memory will recognize that I have given a very sketchy description of one model for short term memory. There is some indication that long term memory involves rather different mechanisms.

Suppose now that the oscillatory pattern set up by an external stimulus has not only a retarded part, which propagates forward in time, but also an advanced part, propagating backwards in time. Although we do not know what equations this pattern would satisfy, it is not implausible that these equations are sufficiently similar to Eq. (1) that both types of solution exist. As in the case of light waves, the relative amounts of the two that are involved in an actual situation is not determined by the equation, and must be decided by experiment. I shall assume that

the advanced part is non-zero, but presumably smaller than the retarded part, since precognition in practice is not a very effective way of getting information. Since the retarded part of the oscillation, which in this model allows memory of the past to occur, is known to persist for at least some time, without great attenuation, it is possible but not certain, that the advanced oscillation would be able to propagate for a corresponding time into the past before the stimulus occurs. So at least over this period of time, by a process similar to memory of the past, it could be possible for the advanced pattern to be brought into consciousness, so that the person involved would "remember" the future stimulus connected with the advanced pattern.

This in brief outline is the model for precognition that I wish to consider. There are several qualitative features of this model that can be simply recognized.

1). One can only "remember" things that one will eventually sense, or learn about through someone else's report. At least this is the case if one disregards the possibility of extrasensory information to be obtained at a later time and rememberd by this mechanism at an earlier time. While this neglect may not be entirely justified, it would seem a useful working hypothesis, since, in any event, the amount of information obtained by extrasensory means is small compared to the other sources I am considering.

2). If the retarded oscillatory pattern is correlated with short term memory, and if the latter has a relatively short term of operation, then we will expect that the advanced pattern would also have a similarly short range into the past. This would imply that precognition would be effective only for events in the not very distant future, perhaps on the scale of hours. Within this time period, precognition would be expected

to show a "decay" curve similar to that shown by ordinary memory. Thus precognition would become easier as the percipient approached to events more closely in time.

However, if precognition became a well controlled ability, it would become possible to "pass" information back indefinitely into the past. For example, suppose someone were going to observe an earthquake at noon, and became aware of it precognitively at 11:45. He could write out the sentence "There will be an earthquake at noon", and show it to other people. The recording of this sentence would then itself become a new stimulus, which could be recognized precognitively sometime before it was real, or ideally, more than the 15 minutes warning gained by the imagined precognition. This process could be repeated indefinitely, and so the warning time increased indefinitely. Of course, several paradoxical results can be reached in this way, and these will be alluded to below.

3). There should be little or no correlation between the spatial location of the primary event and the ability to precognize it. This is because precognition is operating on the future state of the percipients own brain, rather than directly on the distant event. For example, if there were a supernova explosion in a distant galaxy, whose light will reach earth 15 minutes from now, precognition would be able to give a warning of that explosion sometime before the light reaches earth, about as well as it could about an event that occurs in the percipients immediate vicinity.

4). We would expect that the same types of external and internal factors that are known to effect ordinary memory, such as drugs, fatigue, age and training might be expected to have similar effects on precognition. The demonstration of such differential effects would of course be very exciting for parapsychological studies.

5). If we omit from consideration the precognitive "chains" discussed under 2) above, it should not be possible for anyone to precognize about any event that will occur after that persons death, since no sensory input about that event could ever reach his brain. This conclusion is independent of the length of time that the advanced pattern can propagate into the past. It is consistent with one old legend to the effect that prophets cannot foretell their own death, but inconsistent with other legends. Of course, even if it is true that precognition cannot be used to foresee ones own death, other explanations are available to account for this, and it is therefore not a prediction very specific to the present model.

These properties that precognition should satisfy according to this model suggest a number of experimental tests of the validity of the model. Several of these tests will be discussed in the next section.

IV. Tests of the Future Memory Model of Precognition

In order for a model or explanation of any phenomena to have any value, it must be possible to confront it with experimental tests, or to make new observations of the phenomena about which the model makes specific predictions. This is not hard to do for the "future memory" model of precognition, provided always that we have fairly definite evidence that precognition is occurring in a specific instance.

The simplest aspect of the model to test is probably the prediction that a percipient can precognize only those things he will eventually know through ordinary perception. In order to test this prediction, one might first make a search of the literature on precognition to see whether accurate predictions have been made under conditions that preclude the obtaining of the information by the percipient at anytime after the prediction was made. If this turns out to be the case, it would be evidence against the model.

A more convincing test would involve an experiment designed for the purpose. The simplest version of this might be a precognition test in which the results are not ever revealed to the subject. A slightly more sophisticated version would involve a randomized decision pattern for revealing the data a fixed time after the trial. A comparison of the rate of success when the data are revealed as against those in which they are not could indicate the validity or invalidity of the model even if the level of precognition was low.

A possible objection to such experiments is that it is difficult to ensure that the object will never have access to the data at any future time. However, if point

2) above is correct, information obtained long after the trial has taken place would be useless, because of the decay of the advanced pattern at times long before it is established. A test of this point can also be carried out along the lines described above, if it is found that the basic effect exists. To do this, it would be necessary to give information about the data to the percipient at various time intervals after the trial, and investigate how the success rate of precognition would vary with this time delay. If the model is correct, there should be a dependence on time delay that is similar to the dependence of short term memory on the time lapse after the initiating stimulus. I am assuming here that there is no precognitive equivalent for long term memory, as the latter appears to involve a kind of static chemical storage, rather than an oscillating pattern in the brain. If this assumption were wrong, the particular test just described would give negative results, and precognition would be possible of any event up to the death of the percipient. This possibility, while it should be kept in mind, seems less likely to me.

Another testable aspect of the model is that the success rate of precognition should not depend on the spatial location, or any other physical attributes of the event being precognized. This could be tested by varying such attributes of the target, but keeping the information about it eventually furnished to the percipient, and the time advance, constant. Under these conditions the success rate would not be expected to vary, even if the target is at astronomical distances, or is extremely well shielded. These properties are in qualitative agreement with some anecdoted reports of precognition.

Finally, if the model is correct, we would expect precognitive ability to vary

greatly from person to person, just as short term memory does. In fact, it is possible that the same people that have good short term memories would also be good at precognition, although that connection is not definite. Nevertheless, it would be worth testing people with good memories for precognitive abilities. Furthermore, it should be possible to improve precognitive ability by using the techniques that are used to improve short term memory. Probably, these techniques would improve the accessibility of the advanced pattern to the conscious mind, rather than affecting the absolute amount of advanced pattern generated by the event. The latter amount is probably determined by the basic laws by which the brain operates, and not subject to alteration by training.

I believe that if a series of experiments of the type described is carried out with a subject who has real precognitive ability, it would definitely decide whether the memory model of precognition is valid. Perhaps what is even more important, such experiments would furnish much new information about precognition, which would be useful in any case, even if the model should prove wrong.

V. Conclusions and Discussion

Since I believe in a materialist description of natural phenomena, including those involving human beings, I believe that if advanced effects occur in the human brain, they must occur elsewhere in the world, since brains are made of the same kind of matter as other objects are. It therefore appears plausible to me that if the future memory model of precognition is valid, that it should also be possible to detect advanced effects outside of the human brain, perhaps in the type of experiment that Dr. Newman plans to carry out. Conversely, if his experiments gave a positive result, showing that advanced effects do occur, it would lead more credence to the idea that they are what is involved in precognition. Even if the advanced effects are very small compared with the retarded ones, this would not rule out their playing a role in brain processes, provided that they are larger than the "noise" background. It would be interesting to estimate how small the ratio of advanced to retarded effects could be in the brain, and still have the advanced effects be useful; but I have not tried to do this.

Physicists have sometimes raised the objection that any occurrence of advanced effects in nature would lead to unavoidable paradoxes, and causal anomalies. Careful analysis of this question has not substantiated this claim,[2] but the question is not completely closed. However, it should be recognized that if such problems exist, they would also occur just from the existence of precognition, whatever the physical interpretation of the phenomenon. The analyses that have been carried out of possible causal anomalies due to advanced effects could usefully be applied to the precognition directly, rather than to its physical interpretation. I believe that the

limited accuracy of precognition, and especially the impossibility of knowing whether a given precognition will turn out to be accurate until after the event has occurred, eliminate the possibility of such causal anomalies, but it would be worthwhile to carry the analysis through.

Finally, it would be interesting to follow up on a suggestion that is sometimes made, and investigate the extent to which all valid reports of extrasensory perception can be explained in terms of ordinary perception, combined with precognition. My impression is that many such reports can be so explained, but I do not know if they all can be. If it were possible to do so, this would mark a substantial advance in our understanding of these phenomena, and in linking them to other aspects of the physical world that we know better.

References

1. See for example, J. B. Rhine, The Reach of the Mind, (William Sloane Associates, New York, 1947).

2. For example, R. P. Feynman and J. A. Wheeler, Review of Modern Physics, 17, 157 (1945).